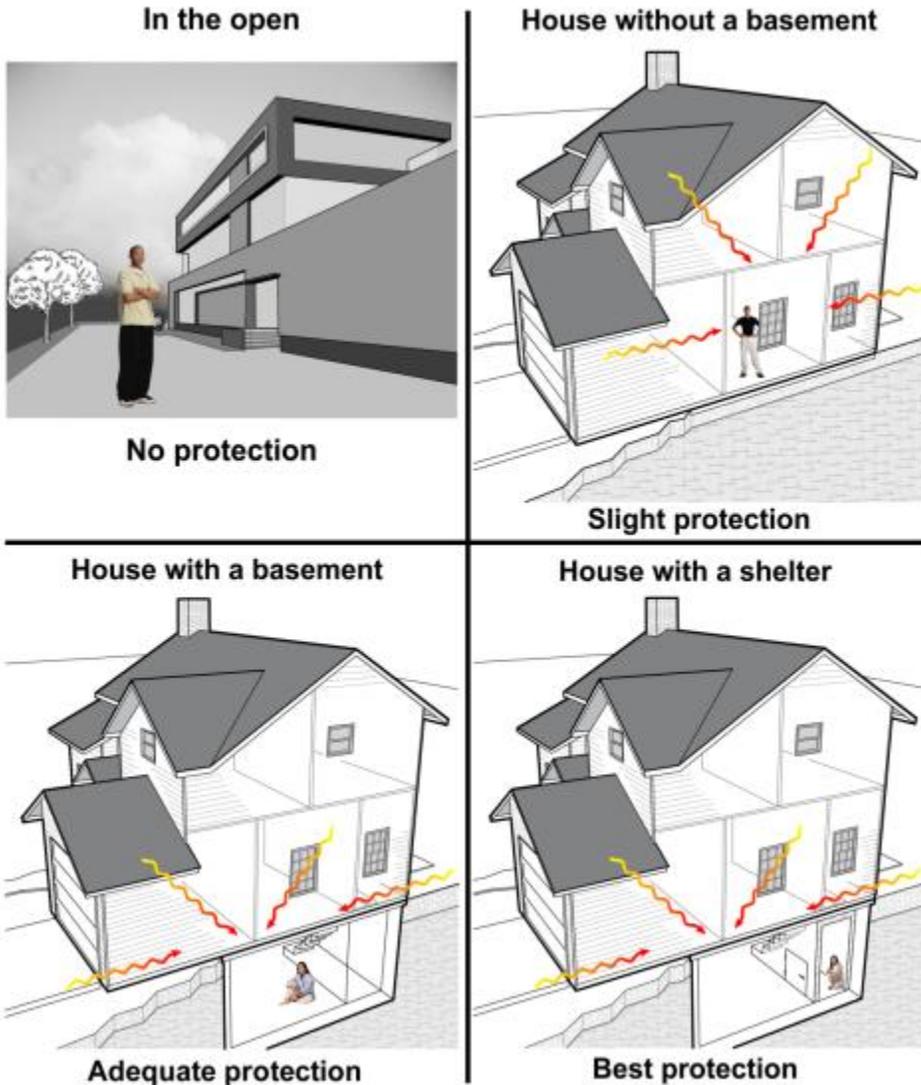


Student Guide: Shelter / Evacuation Strategies



Student Guide: Shelter and Evacuation Strategies (LA)

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FEMA

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Key Fallout Considerations

•Fallout decays rapidly (releasing more than half of its energy in the first hour)

- The radiation levels are very high initially, but over 50% of the energy is given off in the first hour. Over 80% in the first day.

•The primary hazard from fallout is being exposed to penetrating radiation from the particles

- The hazard is the penetrating radiation energy given off by the fallout particles. Getting as much distance and mass between you and the particles is the best protection. By remaining indoors and seeking the best possible shelter in their structure, people can dramatically cut down the radiation dose they are exposed to.

•Dangerous levels of fallout are readily visible as they fall

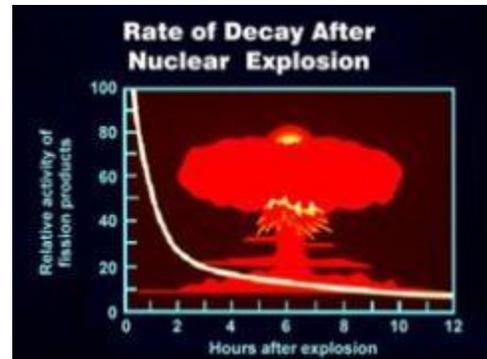
- Dangerous levels of fallout are not invisible; there will be visible quantities of material raining down, often the size of salt or sand.

•Fallout is not a significant inhalation hazard

- Because they are so large, breathing in the particles is not very likely and is a much lower concern than the external exposure from the particles on the ground.

Fallout Images from:

G. R. CROCKER, J. D. O'CONNOR and E. C. FREILING, PHYSICAL AND RADIOCHEMICAL PROPERTIES OF FALLOUT PARTICLES, Health Physics Pergamon Press, 1966. Vol. 12, pp. 1099-1 104.



Images courtesy of Armed Forces Radiobiological Research Institute

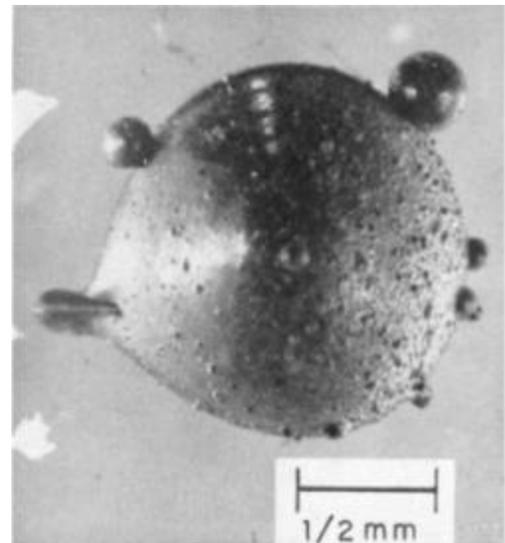


FIG. 1. A radioactive fallout particle from a tower shot in Nevada. The particle has a dull, metallic luster and shows numerous adhering small particles.

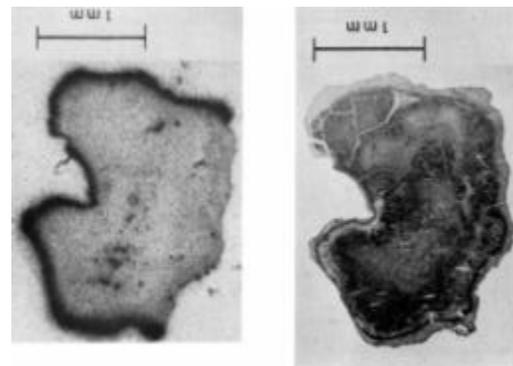


FIG. 2. Through hole (left) and crosshatch (right) of a thin section of an irregular particle from a ground-buried shot in Nevada. The roughness is comparable to the surface of the particle.

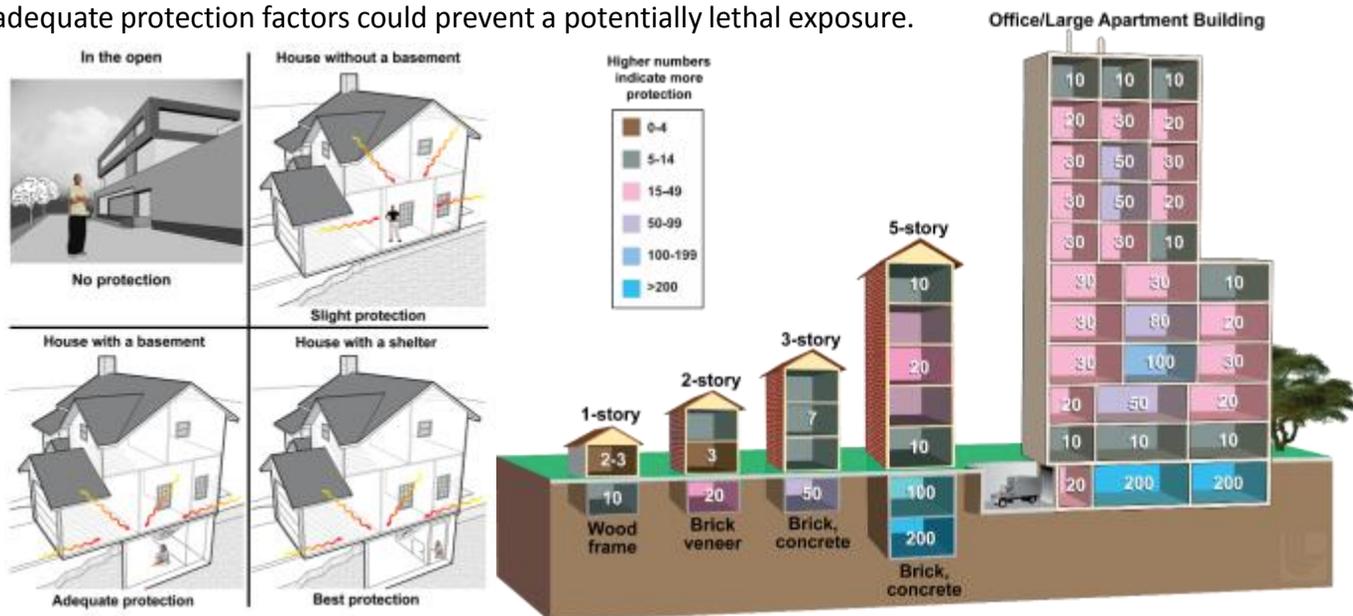
Key Fallout Considerations

•Protection factors

➤As can be seen by this animation, the particles coat the ground and rooftops. The hazard areas are near the places where the fallout accumulates. The radiation penetrates through windows and walls, but exposure decreases with distance and intervening materials.



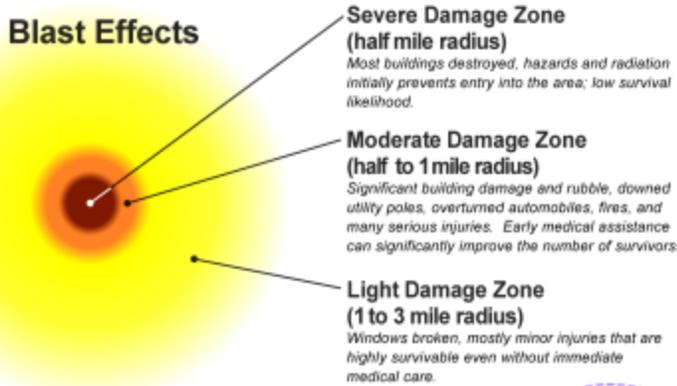
Similar to the SPF of sunscreen; the higher the Protection Factor (PF), the lower the exposure that a sheltered person would receive compared to an unsheltered person in the same area. To obtain the sheltered exposure, divide the outdoor exposure by the PF. This Figure demonstrates presumed protection factors for a variety of buildings and the location within the building. For example, a person top floor or periphery of a ground level of the office building pictured would have a protection factor (PF) of 10 and would receive only 1/10th (or 10%) of the exposure that someone outside would receive. Whereas someone in the core of the building halfway up would have a PF of 100 and receive only receive 1/100th (or 1%) of the outdoor exposure. In fallout areas, knowing locations with adequate protection factors could prevent a potentially lethal exposure.



• **A protection factor of just 10 or higher is considered adequate protection against fallout radiation.** For simple, wood frame houses, just going into a basement is enough to offer adequate protection. For those in large office or apartment buildings, going into the center of the building or deep underground offers very high levels of protection against radiation.

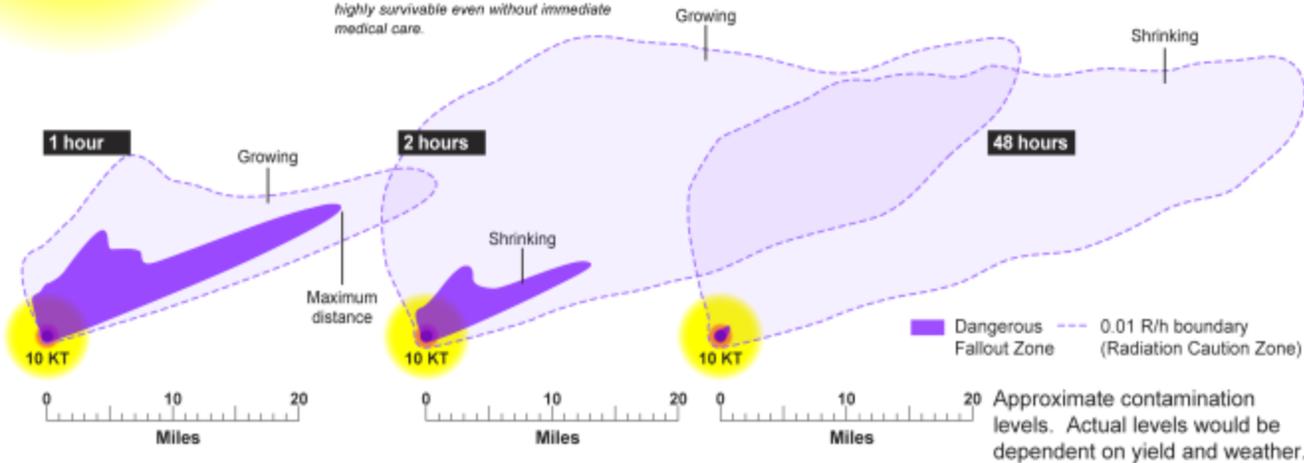
Review the Planning Guidance Zones

Blast Effects



Fallout After Detonation

The Dangerous Fallout Zone shrinks rapidly after a blast. Finding adequate shelter and awaiting instructions for safe evacuation routes could mean the difference between life and death. This example provides approximate ranges for a 10 kiloton explosion, similar to the size of the bomb dropped on Hiroshima.

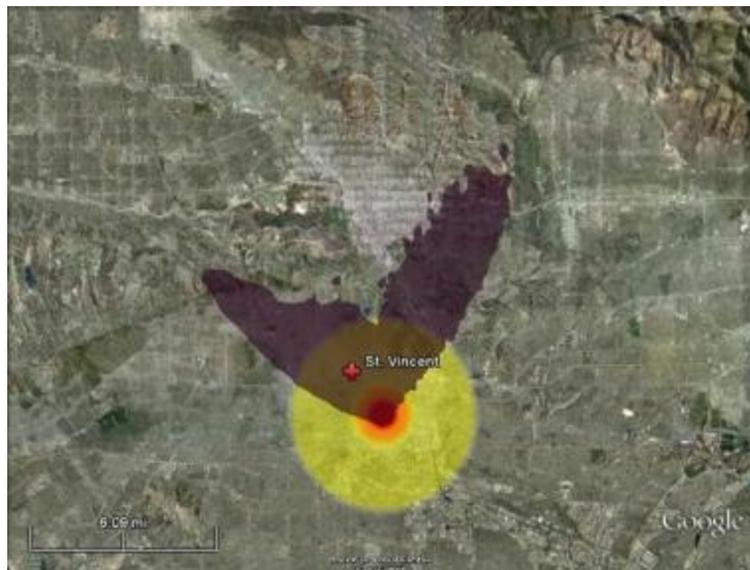


Example Neighborhood

- To help illustrate the type of buildings you would find in a typical L.A. neighborhood, the animation on the PowerPoint focuses on a neighborhood around the St. Vincent Hospital.

✓ This area is ~ 2 miles from the detonation and in the light damage zone.

✓ The area is also in the Dangerous Fallout Zone

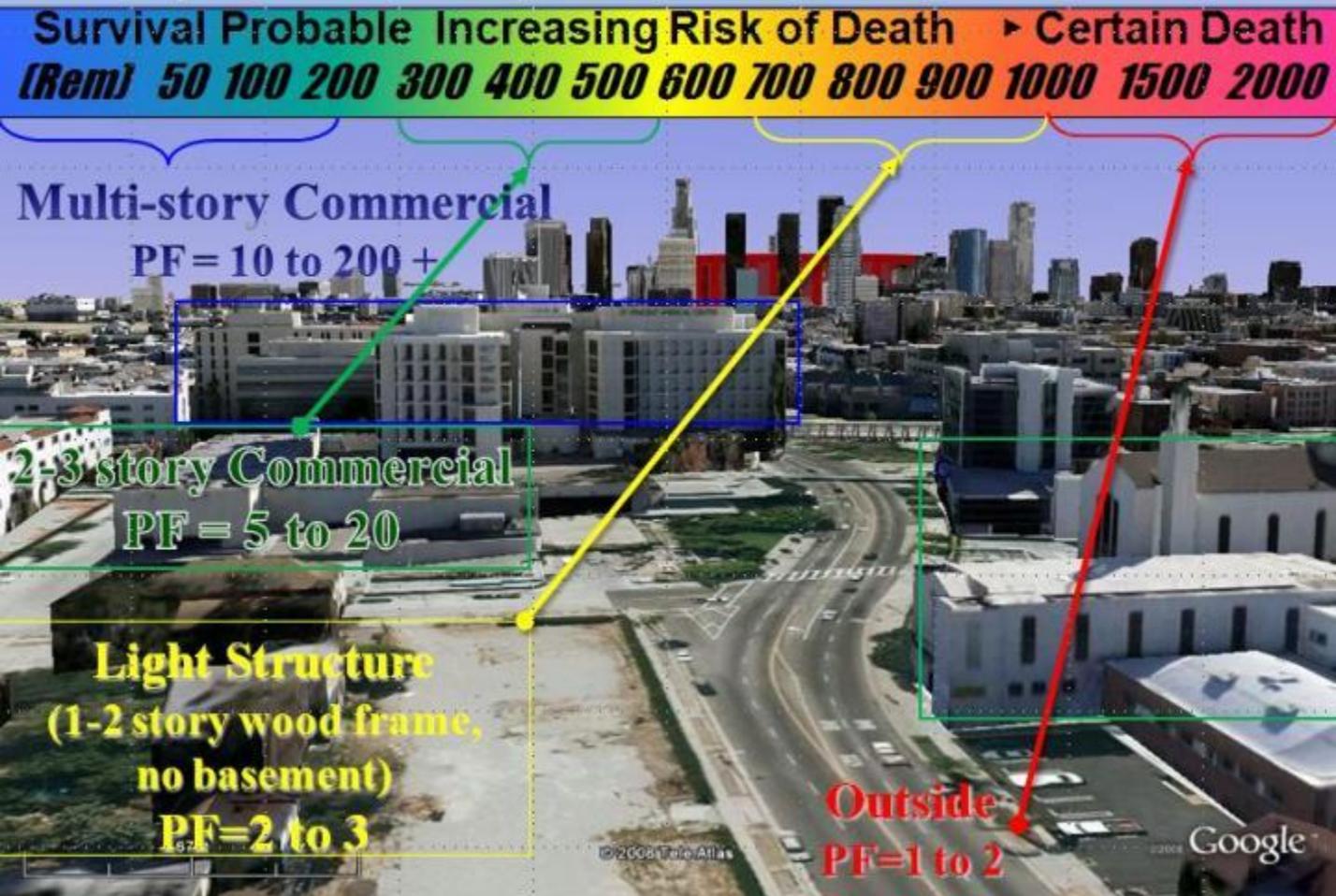




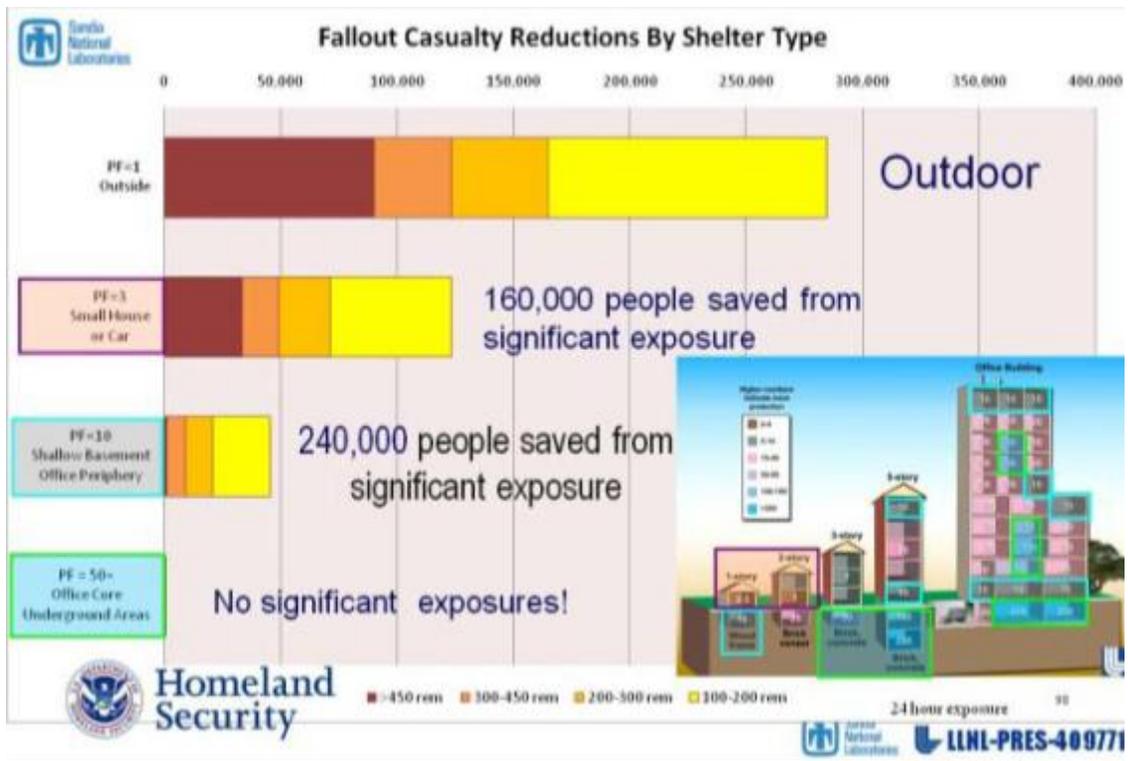
Fallout Exposure Reduction

- For anyone simply standing outside in the first 12 hours following detonation, their dose rate would be 2,000 rem.
- As you can see, a dose that high would be enough to almost certainly kill you.
 - If the only available shelter was a 1-2 story wood-frame house with no basement, there would still be a reduction in dose. However, at this particular location, it is not enough to
- Those seeking shelter in a smaller commercial facility could find protection factors up to 20. People in these types of structures will have survivable exposures.
- For those who can find shelter in a large, multi-story commercial building, their radiation dose will be so minimal that they may not even experience any acute symptoms from the radiation.

Fallout Exposure Reduction



How Many Lives Does It Save?

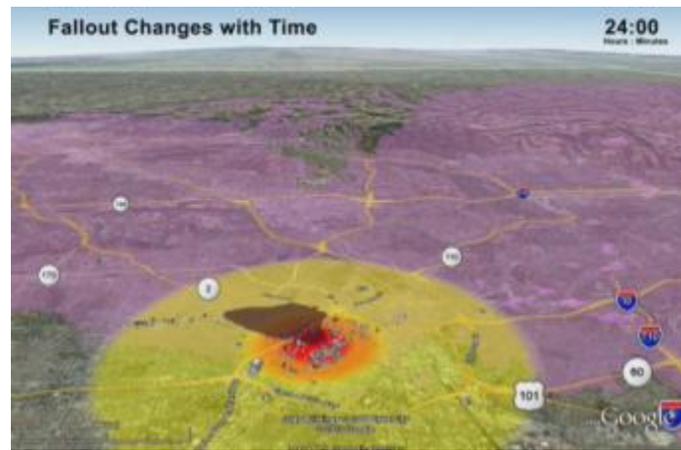
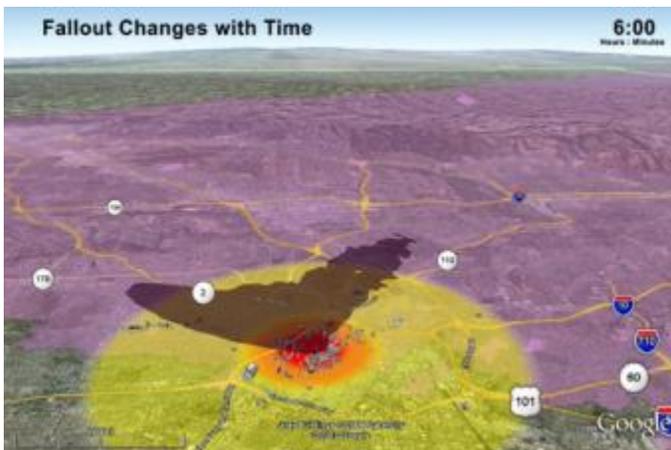
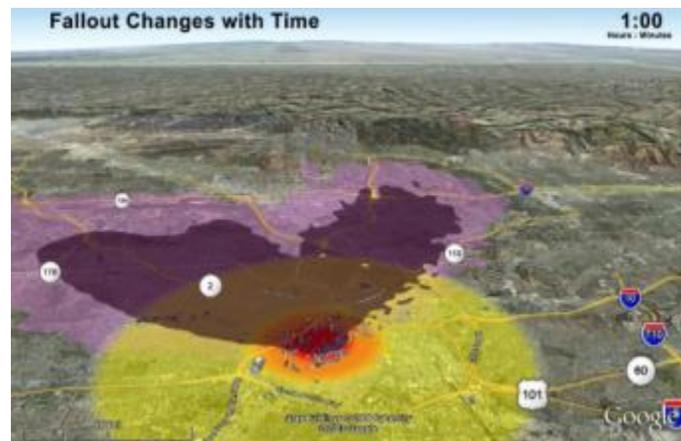


Sandia National Laboratories conducted an analysis of the potential exposures from a variety of sheltering options for the first 24 hours after the detonation of a 10KT. These are only fallout injuries outside of the moderate damage zone.

- If everyone in this area just stood outside for the first 24 hours, ~280,000 people would receive enough radiation exposure to either make them sick (yellow / orange) or kill them (red). Protection Factor of 1.
- Even if everyone went into an inadequate structure like a car or small house, 160,000 people would be saved from significant exposure levels. Protection factor of 1-3.
- If everyone goes into a “just adequate” shelter like a shallow basement, 240,000 people (out of 280,000) would be saved from significant exposure. Also, of the 40,000 remaining exposures, they are in the “sick, but not dead” category. This is why PF=10 is considered adequate. Protection factor of = 10.
- Finally, if everyone could get to the core of an office or an underground basement, there would be no significant exposures to deadly radiation levels. Protection Factor of 50+.

Fallout Changes with Time

- This animation demonstrates the fast nature of radiation. For the first hour after the blast, the Dangerous Fallout zone continues to grow and spread.
- After about an hour, however, the dangerous area starts to shrink. This is due to the short half-life of many of the radionuclides produced. Even though there will always be some amount of radiation left over, most of the dangerous levels decay quickly.



So the key question is “how long should people remain in their shelter?”

Alternate Routes

- Fallout contaminated areas can only be “seen” with special instrumentation
- Uninformed evacuation may result in significantly higher exposures
- For the location of interest, the baseline (BL) evacuation route is presumed
- Alternate routes that go away from the detonation site (Alt-1) or move to the east at a right angle to the direction of the surface wind, sometimes called lateral evacuation (Alt-2), resulted in higher exposures

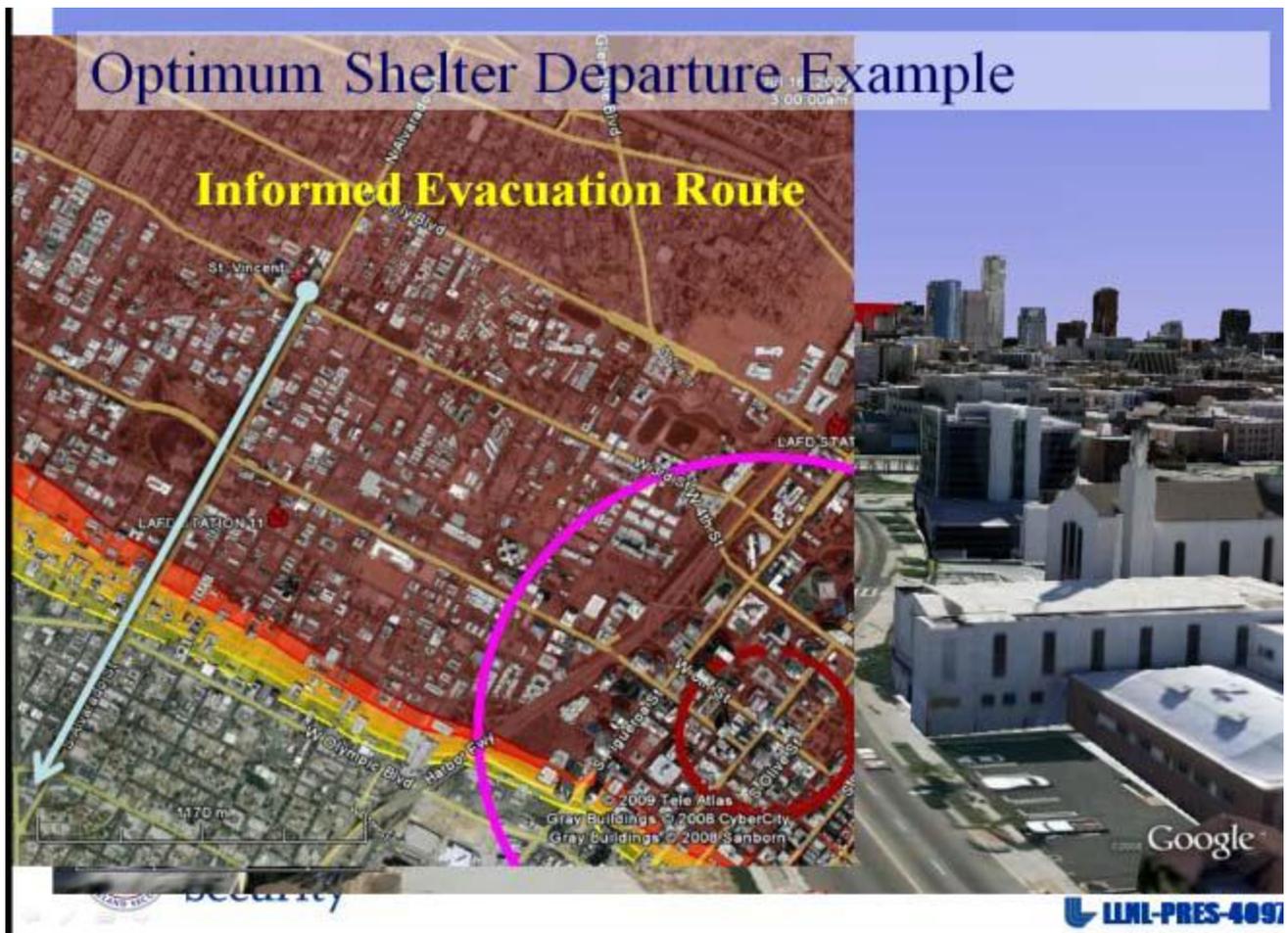


Sandia National Laboratories Analysis of Evacuation Strategies. Source: Image courtesy of Sandia National Laboratories.

Optimum Shelter/Departure Example

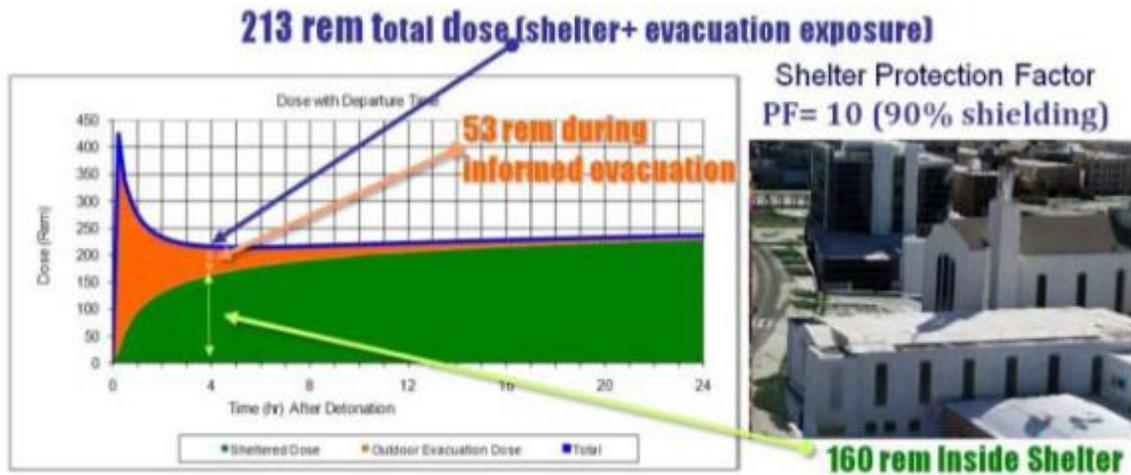
•Informed evacuation route map

- Most people in the Dangerous Fallout zone will likely receive some exposure to fallout; this is, unfortunately, unavoidable. However, knowing how long to shelter and the direction to evacuate can significantly lower the exposure.
- This example presumes an informed evacuation. In this case the best possible route out of the area is SW down S. Alvarado. Unfortunately the victims in this area would not know that without outside help as other routes (away from the blast to the North and toward the freeway to the East) would look just as viable, but result in much higher evacuation exposures.



Optimum Shelter/ Departure Example

This graph shows the total radiation dose received by someone sheltering inside a church with a protection factor of 10 (90 percent shielding). Dose rates will continue to rise depending on how long the person remains inside the church.



For this shelter type and evacuation route:

- Early Departure (< 2 hours) results in significantly higher exposures
- Delayed Departure (>12 hours) results in slightly higher exposures

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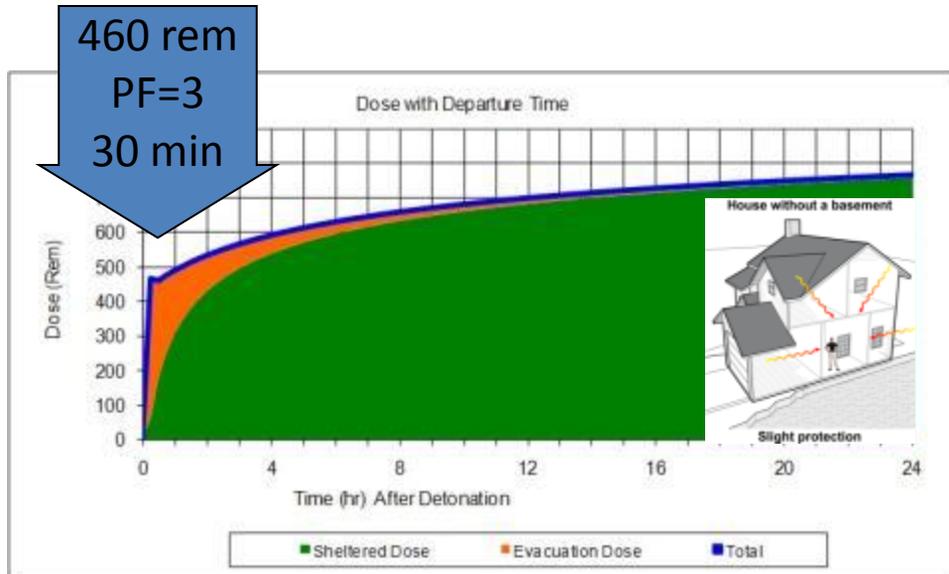
- The orange on the graph represents the additional exposure the person would receive while trying to evacuate the area **at the time specified**.
- Notice how high the evacuation dose is if they were to leave in the first hour. That is because they are trying to evacuate while the radiation levels are highest outside.
- In this example, by waiting four hours to evacuate (the optimum departure time in this case), the person receives the lowest possible dose of radiation.
- Although there is an apparent minimum dose around four or five hours, the slight increase of exposure with time after this point is minimal compared with the hazards of early evacuation.



Optimum Shelter Departure Time Depends on Shelter and Evacuation Route

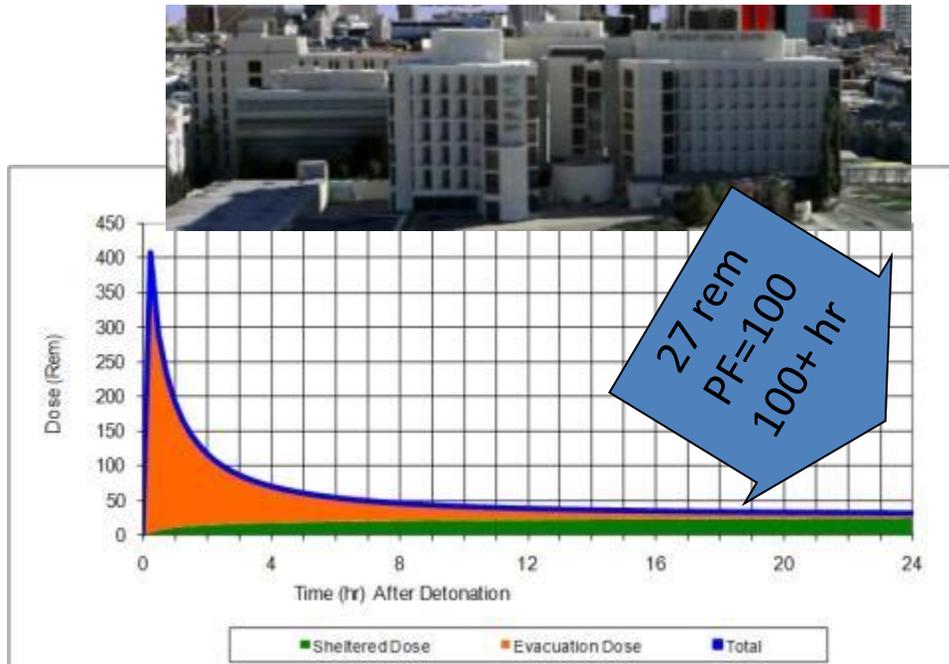
When to evacuate a shelter depends on how much protection a person is getting from the structure, and how long it will take an average person to complete the evacuation route. Knowing the answer to both of these is crucial to creating informed evacuation routes.

- In this example, the wood frame house offers poor protection. Although it does reduce the outside exposure by a factor of three, it is still not enough to warrant staying in the structure for very long. In fact, if the opportunity arises they should consider moving to a structure with more shielding.



- The core of a midrise building, like a hospital, or an underground parking garage, can easily offer protection factors of 100 or more.

- In shelters with protection factors of 100 or more, almost all of the exposure occurs during the evacuation and it is best to wait as long as possible before evacuating. In this example, three days or more is the optimal evacuation time. Again, whether you wait for 12 hours or three days, the difference in exposure is slight compared to the dangerous evacuation doses you would receive in the first few hours.

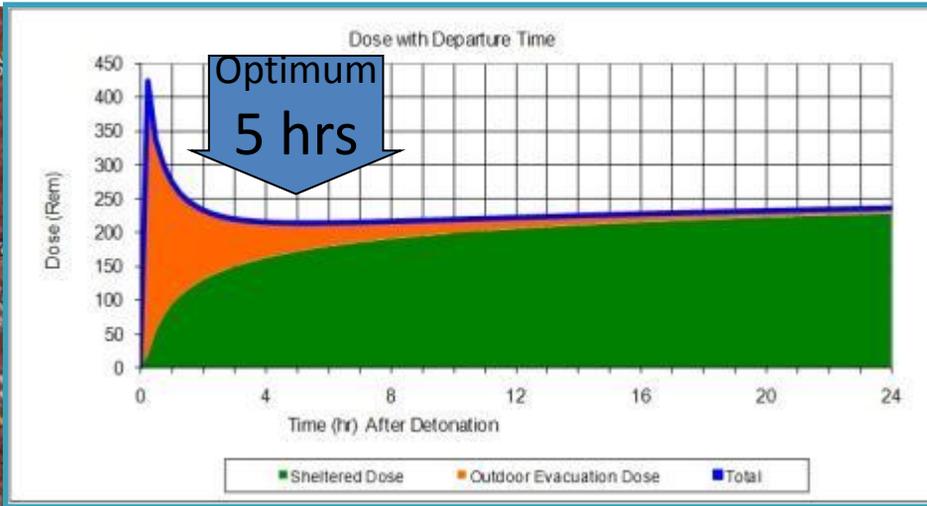
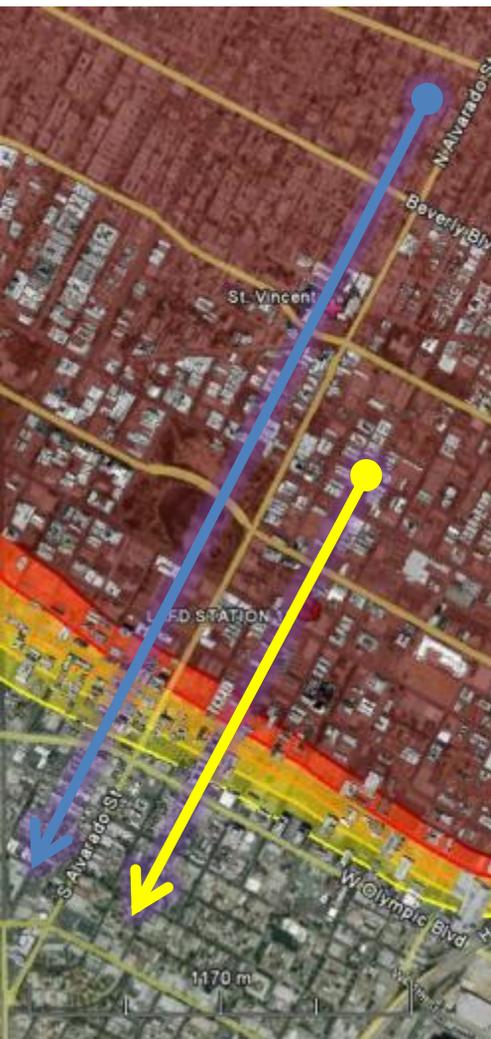


Optimum Shelter Departure Time Also Depends on the Length of the Evacuation Route

• It is also important to consider how long it will take an average person to evacuate using the planned evacuation route.

➤ In this example of two identical buildings with a protection factor of 10, the one closer to the edge of the dangerous fallout zone should evacuate earlier because their overall evacuation exposure is less.

➤ The optimal evacuation for the location near the edge of the DFZ is one hour, whereas the same protection factor building closer to the center of the DFZ should wait for five hours.



This is why rapid hazard zone assessment is important as it drives a number of potential exposure lowering strategies.

Early, adequate shelter followed by informed, delayed evacuation

- Public Protection Strategy: Early, adequate shelter followed by informed, delayed evacuation. This includes:
 - Adequate shelter includes houses with basements, large-multi-story structures, and underground spaces like parking garages or tunnels
 - Sheltering the first hour in an adequate shelter can keep exposures non-lethal
 - Optimal shelter departure time will vary by shelter quality and evacuation path
 - Informed evacuation helps ensure rapid exit of the dangerous fallout zone

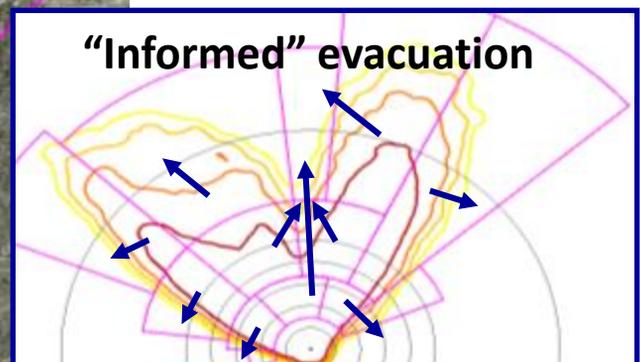
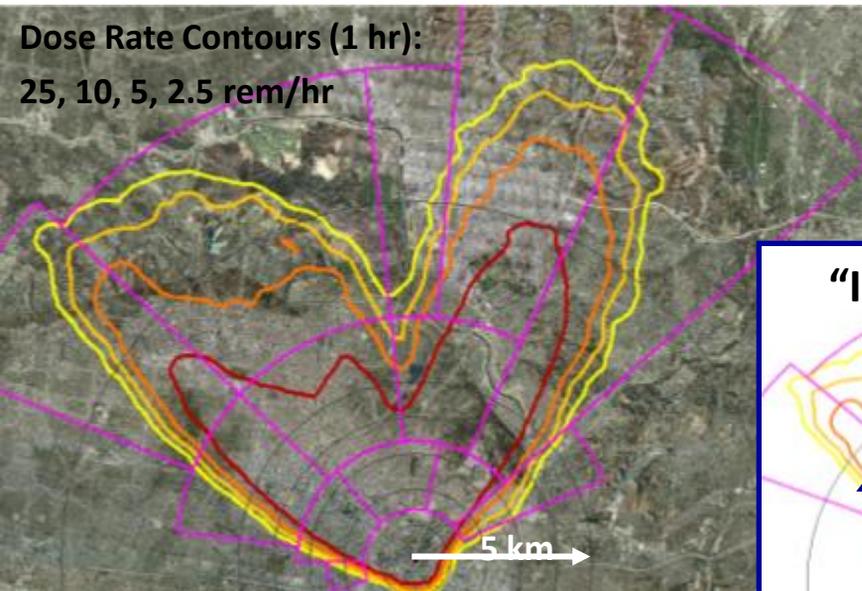
L.A. 10 KT Scenario

- The following slides are from an analysis conducted by Sandia National Laboratory.
- The Fallout region was divided into a number of zones to establish an overall evacuation dose assessment.
- Based on the fallout patterns after one hour, many different evacuation routes are possible.
- After determining routes, it is important to have a plan in place to communicate these routes to those inside fallout zones.
- The following Shelter / Evacuation exposure assumptions presume an **“Informed” evacuation routes attempt to avoid the highest intensity fallout areas.**



Analysis by
Larry D. Brandt and Ann S. Yoshimura,
[“Analysis of Sheltering and Evacuation Strategies for an Urban Nuclear Detonation Scenario,”](#) SAND2009-3299, June 2009

Dose Rate Contours (1 hr):
25, 10, 5, 2.5 rem/hr

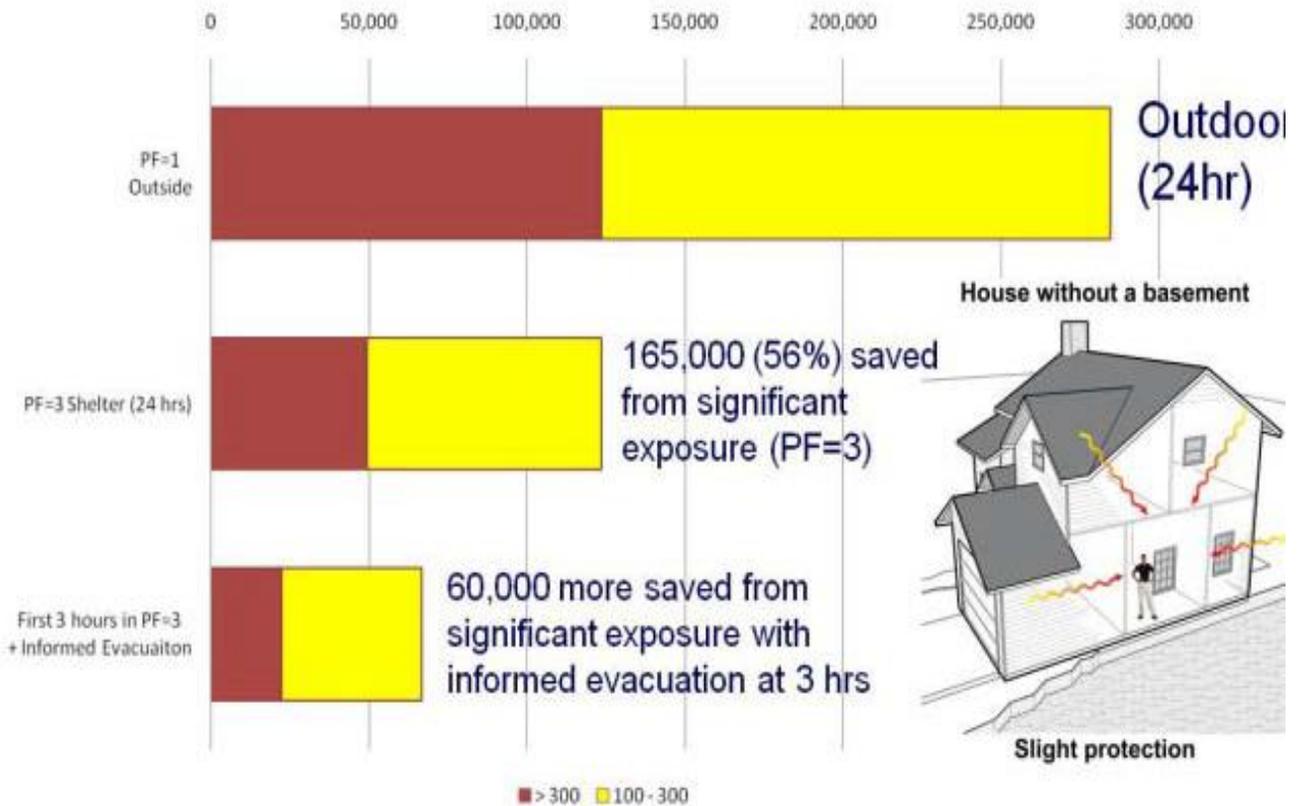




L.A. Baseline Evacuation Results (PF 3 Example)

- Again, this analysis only looks at potential fallout victims outside of the MDZ. If everyone in L.A. stayed outdoors for the first 24 hours of exposure, ~ 280,000 people would receive substantial radiation doses.

Fallout Casualty Reductions for 3 Hour Informed Evacuation



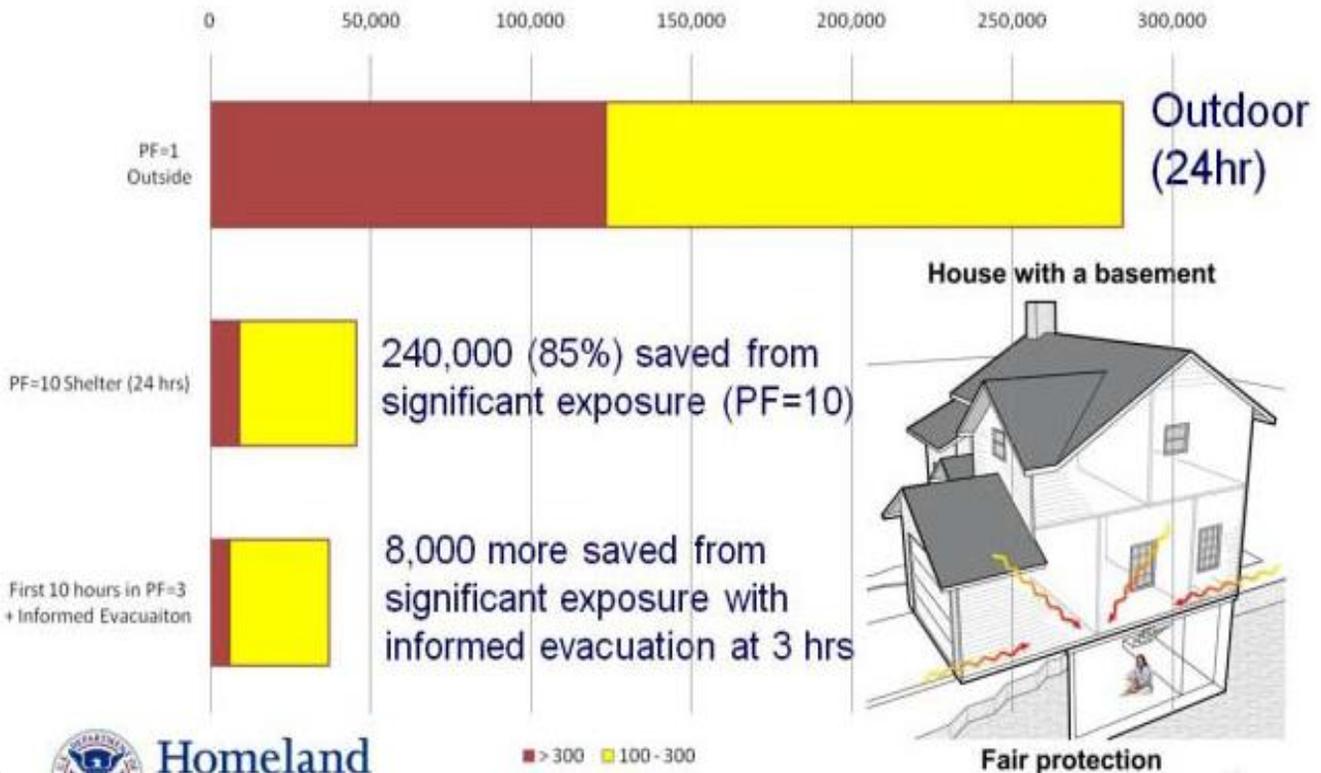
- If residents were to stay in a shelter with a protection factor of three for the first 24 hours, it would be enough to save 165,000 people, or 56 percent of the population, from significant exposure.
- If an informed evacuation at three hours (so three hours in PF=3 building followed by clear, informed evacuation instructions and routes after three hours) is added, another 60,000 (20%) people would be saved from significant exposure.



L.A. Baseline Evacuation Results (PF 10 Example)

- This graph again demonstrates differences in exposure, but uses a protection factor 10 shelter instead.
 - Just like the previous example, if everyone were to wait outside for the first 24 hours, nearly 280,000 people would have significant exposure to fallout radiation.
 - If all residents were able to get in to an adequate (protection factor 10) shelter, like a shallow basement, apartment building or low rise office building, 240,000 people would be saved from significant exposure.
- If those same residents were given informed evacuation plans at three hours, another 8,000 (3%) people would be saved from significant exposure.
- This example demonstrates why adequate shelter (which saved 240,000 for significant exposure) has more dose reduction potential than informed evacuation.
- If an informed evacuation route is available after 3 hours, some additional dose reduction can occur for those in PF=10 or less shelters.

Fallout Casualty Reductions for 3 Hour Informed Evacuation



Evacuation Considerations

Even during the initial (most dangerous) phases of the event, we need to make sure that we do not have “tunnel vision” regarding the radiation hazard and look at all the life safety issues. In particular, it does no good to shelter from the radiation if your shelter collapses on you or is on fire. Be sure that the public knows that other life threatening hazards can take priority.

AFTER THE DFZ IS ESTABLISHED

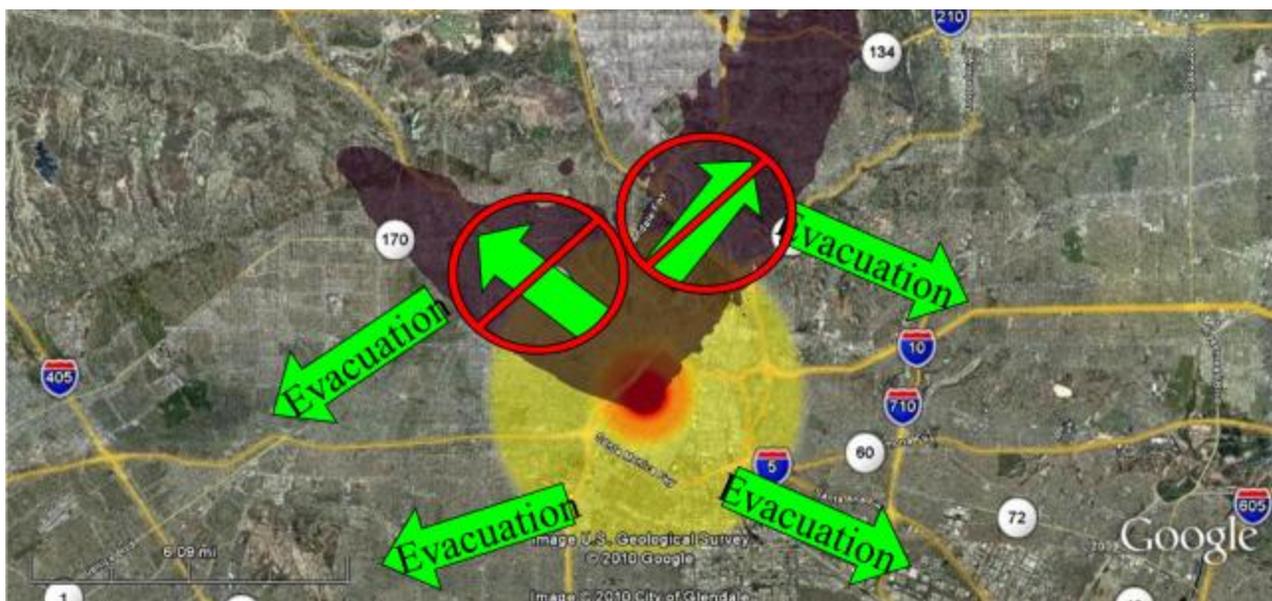
Evacuation planning can begin

- Evacuation routes should be cleared if possible
- Routes that take advantage of sheltered passage (subways, underground connectors, through building lobbies) should be used if possible
- Execution should be phased to reduce the time spent transiting through fallout areas

Evacuation Planning

As stated in the planning guidance:

- When evacuations are executed, travel should be at right angles to the fallout path (to the extent possible) and away from the plume centerline, sometimes referred to as “lateral evacuation.”
- For more complex fallout patterns like the one pictured here, ensure that evacuations **do not** move people down the length of the fallout pattern or into another fallout contamination area.





Preliminary Shelter/Evacuation Analysis

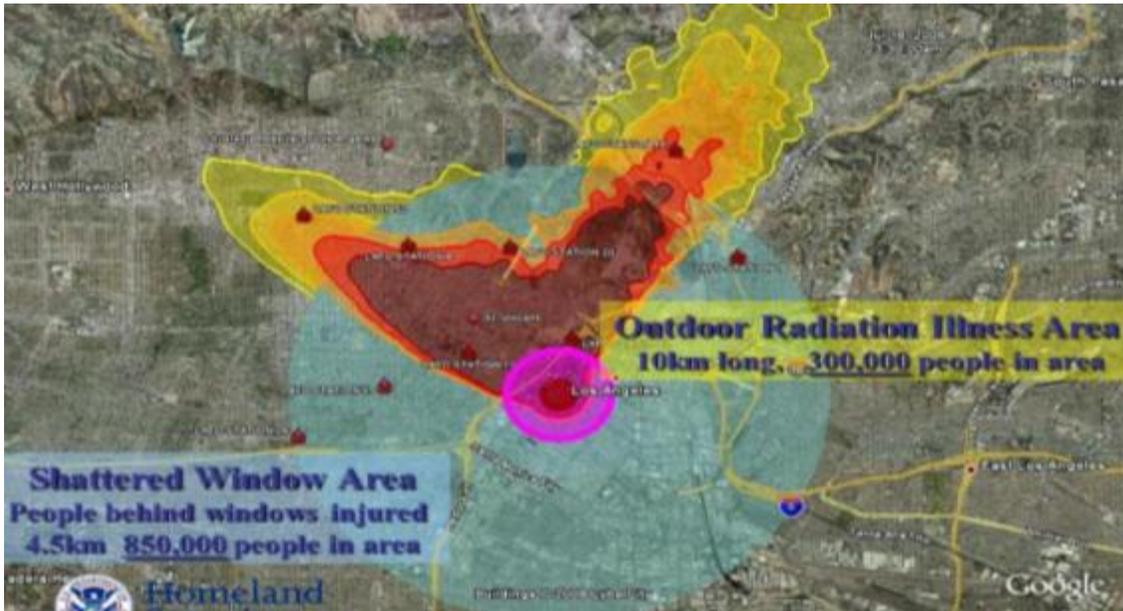
- Spending the first hour in an urban shelter (multi-story building) can keep exposures non-lethal:
 - For anyone who can seek some type of shelter, their chances of significant, deadly radiation exposure levels is dramatically reduced
- Presuming informed evacuation routes and optimum length of shelter stay depends on shelter quality and time required to evaluate the area:
 - Based on what type of shelter a person is in, certain guidelines should be followed:
 - First few hours in a poor shelter (small homes without basements)
 - Several hours to a day in moderate shelters (residential basement, office buildings, small commercial buildings)
 - Several days in good shelters (underground garages, office buildings, deep basements)

However, additional city specific analysis must be performed that takes into account the types of structures and ease of evacuation to be used for planning purposes.

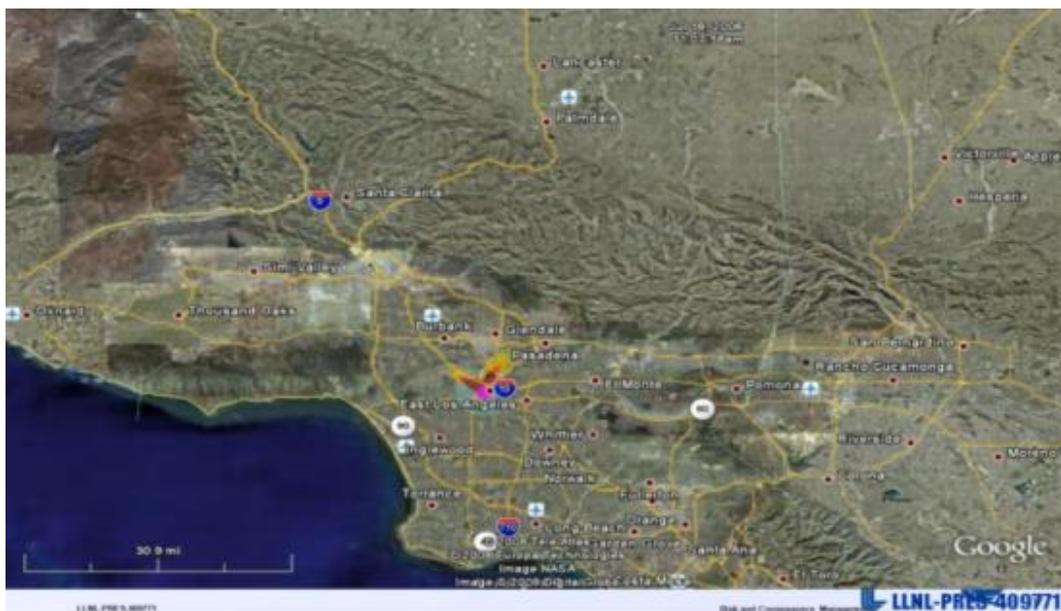


Putting it into Perspective

- This slide demonstrates the areas that can lead to acute effects, the initial blast zones where there could be injuries from flying glass and debris out to 3 miles, and the dangerous fallout area could extend for 10-20 miles.



- As you can see, the areas of potential injury are small when compared to the resources of the area. While it will still be devastating, it is not the “nuclear end-all” situation that many people envision when they think about a nuclear bomb and there are a lot of resources in the surrounding area that can safely help save and sustain lives... If they know what to do!



Weather Matters

- No IND response can be completely preplanned. Weather and yield will greatly affect the direction, extent, and shape of the fallout pattern. As can be seen by the following animation, which demonstrated the fallout pattern from a 10KT modeled using weather from the 15th of each month in 2006, these effects can be highly variable.





Conclusion

- **Public Protection Strategy: Early, adequate shelter followed by informed, phased evacuation**

- With planning, residents can be aware of the dangers of a nuclear detonation, as well as what to do if it happens. People can be made aware that seeking an adequate shelter and waiting for evacuation instructions can save their lives.

- **Response Strategy:**

- *Rapid identification of hazard areas and safe evacuation routes*

- Being able to quickly know where the Dangerous Fallout Zone is, and the best routes based on that, is key to saving lives.

- *Establish public communication (Emergency Alert System)*

- Reestablishing emergency communication channels and immediately broadcasting safety messages is important to public safety.

- *Identify priority candidates for early shelter departure*

- Residents in inadequate shelters should be given priority when planning evacuation routes, as they will need to begin evacuation first to avoid lethal doses.

- **First hour most critical**

- Residents need to know to immediately seek shelter.

- **100,000s of people can be saved through proper action**

- Having informed evacuation plans in place will save many people from significant radiation doses.

- **Situation awareness, communication and independent responder actions is essential**

- Knowing what to do when an IND detonates is important and will save lives.

- **Knowing what to do before the event is critical**

- Having response plans, knowledge about fallout, and training will save countless lives after an IND detonation.





Check Your Understanding

1. What is a protection factor and how is it used?
2. When are the radiation levels highest outside?
3. What does the optimum shelter departure time depend on?
4. What is the best action to take to avoid lethal radiation exposure?
5. How and why does the weather matter?

